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Rufus P. Williams,
June 3, 1902.

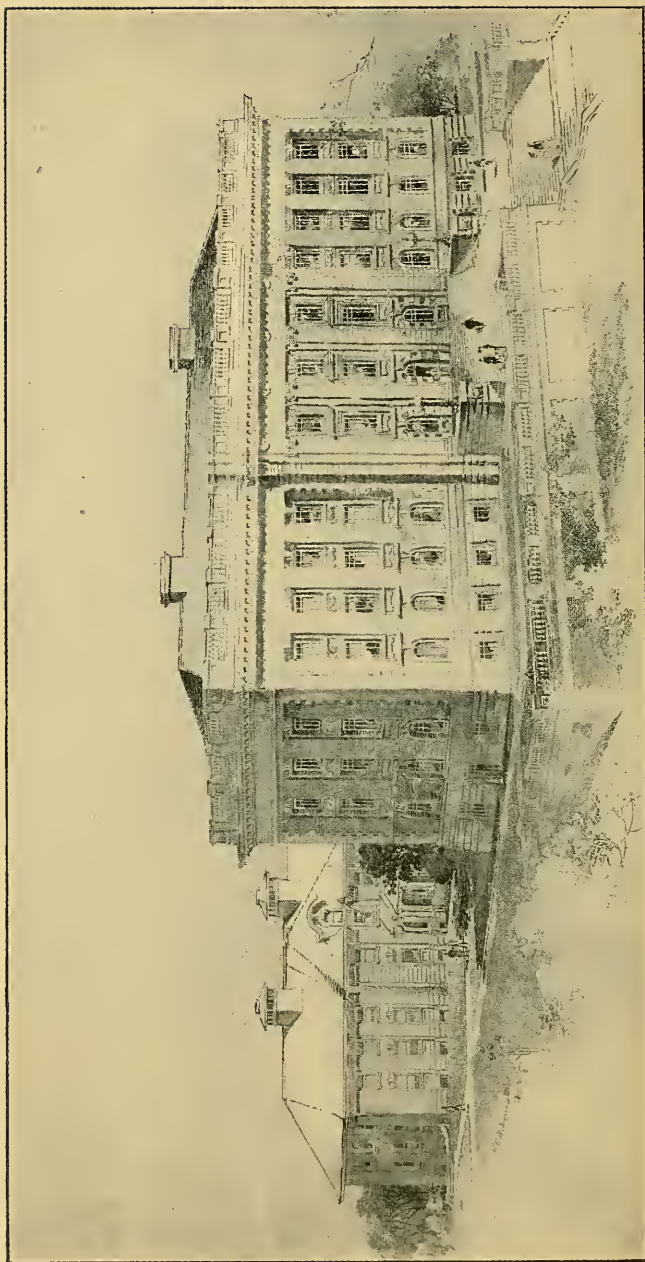
THE NATIONAL BUREAU OF STANDARDS.

BY RUFUS P. WILLIAMS.

This institution is one whose prospective value to exact science in America can hardly be overestimated. In creating it the 56th Congress passed an act which each succeeding year has rendered more necessary. In the early days of our history every colony had its own standards of weight and measure, which were later adopted by the various states. These standards differed widely. When the colonies became a nation, though the Constitution gave authority to Congress to make one uniform standard, and Washington in his first message recommended it, it was still left to the states. As there was no call for exactness and "pretty near" would then do for comparative measurements, there was no need of a bureau, hardly of a bureau drawer. But as soon as Uncle Sam began to do his own work a standard must be had, and this the Coast Survey first introduced.

Nothing came of Robespierre's effort—when in 1794 he sent over from France a copper meter stick and a kilogram weight of the same metal—to induce the United States to adopt the metric system. It was not till 1814 that a standard of length—the Troughton 82-inch brass bar—was brought from England, the distance between two lines on that bar being adopted for use as the yard in the survey of the coast. In 1821 the first platinum meter and kilo were imported, and in 1827 came the Troy pound, of brass, from England. This latter was the only one of all having the sanction of Congress.

The need of uniformity was emphasized in 1830 when the Senate ordered a comparison of the measures and weights at the various custom houses in the United States to be made, and found large discrepancies. Eight years later the Secretary of the Treasury was ordered to distribute to the governor of each state a set of all the weights and measures which he had adopted as standards.



THE NATIONAL BUREAU OF STANDARDS.

Then followed, in some cases, the passage of state laws confirming the government measures. In this manner was partial uniformity established. The passage by Congress of the metric act in 1866 and the distribution of metric weights and measures to all the states, was followed by the convention at Paris in 1875, and the founding in that city of the International Bureau of Weights and Measures, and in 1889 by the transmission to the United States of the national prototype meter and kilogram, which have ever since been the final appeal for length and weight in government work. These and other standards were kept in the Treasury Department, in the custody of the Superintendent of the Coast and Geodetic Survey, until July 1, 1901, when they were turned over to the Director of the Bureau of Standards.

With a century's growth of exact science the need of standards and standardizing apparatus has enormously increased. Instead of the pound, foot, gallon and bushel of our fathers—manufacture, trade and the arts of modern life demand the testing of such appliances as balances, weights, apparatus for the measurement of capacity and length, thermometers, pyrometers, meteorological apparatus, barometers, hydrometers, instruments for testing oils, sugars, alcohol and other liquids, also those used in navigation, surveying and hydrography, photometers, gas meters, wattmeters, volt and ammeters, magnetometers, speed indicators, steam-engine indicators, pressure gauges, graduated chemical glassware, apparatus for testing the strength and other properties of materials, etc. All these must be the refinement of accuracy, and must have skilled specialists to make and adjust them.

To the present time there has been no suitable place for keeping the few standards the government owns. The weights have been kept in a coal vault, subject to more or less moisture and temperature changes. The need of standardizing apparatus and of experts to direct the processes will be more apparent after considering half a dozen of the above cases.

(1) Take the graduation of thermometers and pyrometers. Such work is now done in Germany and England. In 1897 more than 100,000 thermometers were standardized in Germany. In the Kew Observatory in England some 18,000 chemical ther-

monometers were tested. We cannot do the work in this country now, but it will be one of the functions of the new bureau. As one single illustration of the value of precise measurements, the government saved \$125,000 by being able instantly to know the exact change of temperature in the process of shrinking a jacket on a 16-inch gun. The need of such standards is increased by the very low and very high temperatures now made available in scientific work.

(2) It is perhaps enough to say of barometers that all standardizing has to be done abroad, as in the case of thermometers.

(3) In many instruments an accurate standard is of great financial importance as well to government as to corporations. The annual duty on sugar, for example, amounts to some \$60,000,000 and is based on the reading of the polariscope, an error of one-tenth of one per cent in the readings making a difference of \$60,000 on the duty. A suit against the government has been pending for a long time. It hinges on the question of polariscopic reading, and there is no government standard to which to refer the quartz plates used in the readings.

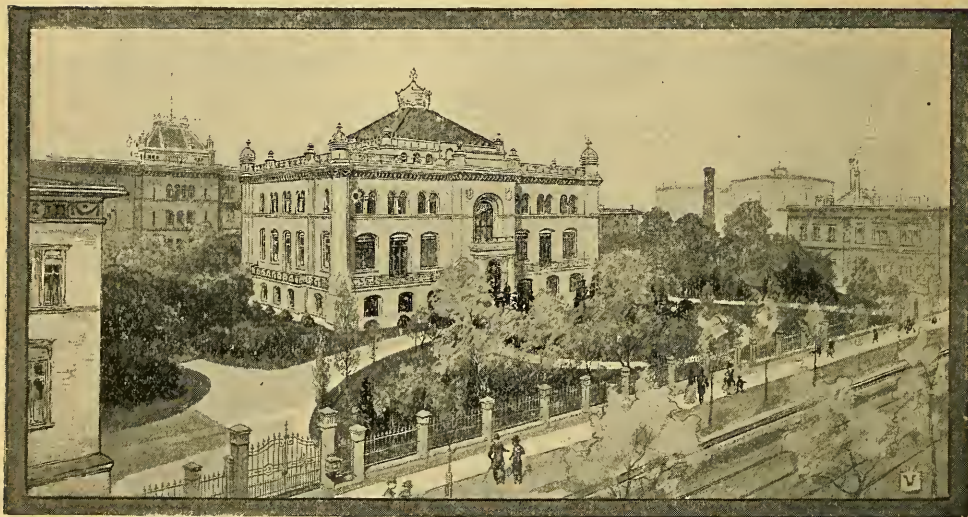
(4) Photometric measurements are also of commercial value. The absence of a standard candle has forced one large electric company to establish a lamp-testing bureau of its own. From every barrel of 200 lamps sent the company ten are taken at random and if any one of these falls below 15 candlepower or is above 17, for a 16 candle, the entire barrel is rejected. But even these standards soon deteriorate and new ones must be obtained from experts. They, like the other standards, come from Germany. A similar test is made of the energy of consumption, five to six million lamps being annually tested by the bureau of this company. The lack of government standards has led to more serious results. The late Professor Rowland testified before the Congressional committee that a certain electrical association voted to call each arc light 2,000 candlepower (if it required 10 amperes of current at a pressure of 45 volts) when in reality it gave only from 400 to 500 candlepower. The consumer thus pays for and supposes he is getting a 2,000 candle light. Even if he knew better there would

be no legal redress, for the law fails to define a candlepower as regards electric lights. Our ideas and laws on this question come from England where many years ago, when gas was introduced in London, Parliament adopted as a standard candle one of definite composition which would burn 120 grains an hour with a government wick. The *incandescent* light companies in this country attempted to employ that standard, which is the legal one, as applied to gas.

(5) The revenue collected on liquors in the United States amounts to about \$110,000,000 yearly and is based upon hydrometer readings, for which we have as yet no government instrument to refer to. Oils, acids and other liquids are similarly tested.

Enough has been said to indicate the great need, from a commercial as well as a scientific point, of a national standardizing bureau. Without going much into the history of similar institutions in Europe, let us refer briefly to one. Not to mention one of the earlier receptacles for standards in the British exchequer, nor to dwell on the International Bureau constituted in Paris in 1875—by reason of which France became the leading metrological nation of the world—we come to the more recent and best equipped of all standardizing plants, viz.: that of Germany. The commercial and manufacturing prestige which this latter country has lately developed is thought to be due in no small part to the accuracy and scope of its standardizing equipment. To the Reichsanstalt people have gone for instruments of precision, and German manufacturers have taken advantage of the accuracy of these to sell their wares to countries less favored. The Reichsanstalt is situated at Charlottenburg, a suburb of Berlin, and is the gift of Dr. Werner Siemens. Its general plan was outlined in 1887. It has two objects—research in pure science and the cultivation of precision in the technical application of science. The most distinguished physicist of the realm is sought as official manager. Helmholtz was the first incumbent, and at present Professor Kohlrausch is its head. The Reichsanstalt has cost over a million dollars and there are nine buildings. Its annual maintenance costs \$75,000 and 95 experts are employed. Papers of research

work are published from time to time on various topics—heat, light, electrical work, chemistry and mechanical precision, such, for example, as the investigation of the hydrogen thermometer, the thermal and electrical conductivity of pure metals from the temperature of liquid air up to $1,000^{\circ}$ C. By the thermo-electric couple temperatures have been measured as high as $1,775^{\circ}$ C., while with a petroleum-ether thermometer 190° C. below zero is obtained. Here are the most sensitive scales in the world. One



From PEARSON'S MAGAZINE.

THE REICHSANSTALT BUILDINGS AND GROUNDS.

of the two institutions under the control of the Reichsanstalt for the calibration of thermometers has tested 350,000 during the last ten years.

England has lately created a bureau of its own on somewhat similar lines to the one in Germany. The bill for our own National Bureau of Standards was drawn up at the suggestion of Pres. Henry S. Pritchett by Dr. S. W. Stratton and others, and was approved March 3, 1901. A building site, consisting of some eight acres, has been selected in the northern suburbs of Washington on

an elevation near Rock Creek Park, so situated as to be free from mechanical and electrical disturbances.

The two buildings to be first erected and the fittings are expected to cost \$300,000 and to be ready for occupancy in about a year. Professor Samuel W. Stratton, formerly of The University of Chicago, has been appointed director. It is hoped to make this bureau second to no similar institution in the world. To it states, corporations and individuals may refer questions concerning all sorts of measurements.

Both directly and indirectly this bureau will exert a strong influence for the adoption and use of the metric system. It is probably the greatest step in that direction taken by Congress since 1866. The director and his corps of assistants—specialists of the highest training—will come in touch on the one hand with manufacturers of goods for both domestic and foreign consumption, and the latter means a constant reference to metric weights and measures; on the other hand they will render expert testimony to Congress in general and to the committee on coinage, weights and measures in particular. As scientific experts their influence will always be on the side of metric reform. Dr. Stratton recently said: "There is no doubt in the mind of any thinking person but that a universal system must soon be adopted, and no system offering advantages equal to that of the metric system has yet been devised."

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